PCT/GB 2004/001526

GB04/1526

INVESTOR IN PEOPLE

The Patent Office

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

REC'D 18 MAY 2004

WIPO PCT

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed M Cooki

Dated 7 May 2004

PRIORITY DOCUMENT
SUBMITTED OR TRANSMITTED IN
COMPLIANCE WITH
RULE 17.1(a) OR (b)

Patents Form 1/77

Patents Act 1977
(Rule 16)

THE PATENT OFFICE
09 APR 2003
RECEIVED BY HAND

The Patent Office

1/77

10APR03 E799064-1 D00041
P01/7700 0.00-0308197.3

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

09 APR 2003

The Patent Office

Cardiff Road
Newport
South Wales
NP9 1RH

1.	Your reference	MJB07267GB
2.	Patent application number *(The Patent Office will fill in this part)*	0308197.3
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	The Technology Partnership plc Melbourn Science Park Cambridge Road Melbourn Royston Hertfordshire SG8 6EE
	Patents ADP number *(if you know it)*	6771901001
	If the applicant is a corporate body, give the country/state of its incorporation	United Kingdom
4.	Title of the invention	GAS FLOW GENERATOR
5.	Name of your agent *(if you have one)*	Gill Jennings & Every
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	Broadgate House 7 Eldon Street London EC2M 7LH
	Patents ADP number *(if you know it)*	745002 ✓
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country / Priority application number *(if you know it)* / Date of filing *(day / month / year)*
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application / Date of filing *(day / month / year)*
8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	YES

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	5
Claim *(s)*	
Abstract	
Drawing *(s)*	4 ×4

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	NO

11. For the applicant
Gill Jennings & Every

I/We request the grant of a patent on the basis of this application.

Signature Michael J Brunner   Date 9 April 2003

12. Name and daytime telephone number of person to contact in the United Kingdom

BRUNNER, Michael John
020 7377 1377

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.*

b) *Write your answers in capital letters using black ink or you may type them.*

c) *If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.*

d) *If you have answered 'Yes' Patents Form 7/77 will need to be filed.*

e) *Once you have filled in the form you must remember to sign and date it.*

f) *For details of the fee and ways to pay please contact the Patent Office.*

GAS FLOW GENERATOR

The present invention relates to a gas flow generator and, more particularly, to a gas flow generator incorporating a piezoelectric or electrostrictive device.

Modern electronic devices, particularly portable devices such as laptop computers, mobile telephone and the like are becoming ever more powerful, thus increasing the amounts of electrical power used by, in particular, microprocessors employed in such devices, and therefore there is a growing need for cooling of such microprocessors. Cooling is also required in electro-chemical batteries and other gas flow requirements are to be found in, for example, fuel cells.

Various types of cooling are known, for example using fans, heat pipes or Peltier devices, but these suffer from a number of problems such as expense, noise, power consumed or size, for example. It has been proposed, see US-4753579-A, to utilise a piezoelectric transducer to cause movement of a blade, which may be tapered and which may carry a hinged perforated membrane, acting as an amplifier to cause a flow of gas around the blade.

It is also known, see US-5914856-A to utilise a piezoelectric driver in conjunction with a one way valve to cause a flow of gas. However, the requirement to provide highly miniaturised valves is problematic since they are both expensive and prone to failure.

The present invention is aimed at providing a sufficiently strong and efficient gas flow from a thin-walled device capable of being provided with a low profile and having light weight which additionally does not require the use of separate valves.

According to the present invention there is provided a gas flow generator comprising an ultrasonic driver comprising a piezoelectric or electrostrictive transducer mounted on a substrate, operation of the transducer being arranged to cause the driver to bend;

a first membrane disposed on or formed integrally with the transducer or the substrate; and

a second membrane mounted substantially parallel with the driver and spaced a given distance therefrom,

one of the membranes being perforate, whereby ultrasonic bending of the driver on actuation of the transducer causes a gas flow through the perforate membrane.

The perforate membrane may be either or both of the first or second membranes.

Preferably, the ultrasonic driver has a piezoelectric transducer having a thickness substantially the same as the substrate to which it is mounted, the substrate and the piezoelectric transducer having substantially comparable stiffness which, when the transducer is caused to expand (substantially in the plane of the driver) causes the driver to bend, carrying the first membrane with it. WO-93/10910-A discloses a piezoelectric actuator of a similar type employed for the generation of fluid droplets.

The driver may be operated at mechanical resonance to produce large amplitude vibrations in the bending mode. An annular ultrasonic driver may be used, in which case the substrate may include, either integral or mounted thereon, a non-perforate membrane effectively closing the central aperture in the driver, with gas flow through the opposing perforate membrane spaced from the substrate, or the perforate membrane may be integral with or mounted on the substrate with the non-perforate membrane being opposed. A further embodiment may include two perforate membranes, one on the substrate and one opposing it, gas flow being through both.

The perforate membrane may then be supported on the substrate of the driver by a spacer, for example, a generally annular spacer and an opening can be provided through the spacer to allow gas flow into the cavity formed between the driver and the perforate membrane. In use the volume of the cavity alternatively expands and contracts creating a differential pressure and hence a gas flow through the device.

In an alternative construction the first membrane is perforate and gas flow is through the aperture in the annular driver.

The gas flow can be used to cool microelectronic and other devices as mentioned above or to supply gas flow for other purposes though devices requiring a gas flow therethrough.

Examples of gas flow generators constructed in accordance with the present invention will now be described with reference to the accompanying drawings in which:

Figs. 1 and 2 are cross-sections through thin-walled ultrasonic drivers which may be used in a generator of the present invention;

Figs. 3 and 4 illustrate plan views of the same drivers;

Figs. 5 and 6 illustrate two further drivers, in plan view, but rectangular in outline, rather than circular as in Figs. 3 and 4, but having substantially the same cross-section (see therefore Figs. 1 and 2);

Figs. 7 and 8 illustrate the bending modes of the drivers of Figures 1 and 2 respectively;

Figs. 9, 10 and 11 illustrate examples of generators according to the present invention in cross-section;

Fig. 12 is a plan view of the generator shown in cross-section in Fig. 11; and

Figs. 13 and 14 are graphs showing typically membrane separation during actuation of the driver and corresponding pressures developed within the cavity between the membranes, respectively.

Figures 1 and 3 illustrate a first ultrasonic driver 1, in the form of a disc 2 of a piezoelectric material (e.g. PZT) bonded to a larger diameter disc of stainless steel 3 on one side, on the other side of the stainless steel 3 disc being bonded a circular stainless steel membrane 4. An active ultrasonic driver is formed by connecting electrodes on opposite sides of the piezoelectric disc 2 (which are not shown - for purposes of clarity) so that when an electric field is applied across the piezoelectric disc 2 and it responds by attempting to change shape, as long as the substrate 3 and the piezoelectric material 2 are of comparable stiffness, the driver is caused to bend and when operated at mechanical resonance, large vibration amplitudes can be created. In turn therefore the stainless steel membrane 4 is flexed.

A similar driver is shown in Figures 2 and 4 and the same reference numerals are used for simplicity, but in this case the piezoelectric and the substrate are annular. The stainless membrane is circular and effectively closes the aperture in the centre of the substrate 3.

Corresponding linearly-acting, rectangular drivers 11 are shown in Figs. 5 and 6 with the same numbers being used for similar components for ease of reference.

The bending modes of the drivers shown in Figs. 1, 3 and 5 and 2, 4 and 6 respectively and used in the generality of Figs. 9 to 11, are shown in Figs. 7 and 8.

The driver shown in Fig. 2 is incorporated in a gas flow generating device as shown in Figs. 9, 10 and 11. In the device shown in Fig. 10, a second stainless membrane 5 is shown spaced at a suitable distance from the membrane 4, held in position by an annular 6 and forming a cavity 10. The centre part of the stainless membrane 5 has perforations 7 through it which may be in the form of tapered or non-tapered orifices. The tapered orifices may be forwardly tapered, i.e. narrowing in the downwards direction as shown or reverse-tapered, i.e. narrowing in the upward direction as shown in Fig. 10.

In the example generator shown in Fig. 9 the membrane 4 is deformed at its centre and is closely spaced from the membrane 5 which is held at a greater distance from the driver 1 by a spacer 6' thus providing the cavity 10 between the membranes with a larger volume.

The example generator shown in Fig. 11 is broadly similar, but avoids any coupling between the membranes 4 and 5 by supporting the membrane 5 via the spacer 6" on an annulus 8 which is connected to the substrate 3 by spokes 9 (see Fig. 12).

In operation of all of the devices shown above, when the driver is operated, the membrane attached to the driver is caused to vibrate so that the cavity between the membranes alternately expands and contracts. Asymmetry, resulting either from the size, shape or direction of tapering of the holes or in the actuation of the driver, enables a differential pressure to be generated within the cavity as shown in Fig. 14 so that a gas flow is caused between the inside and the outside of the cavity 10. In the device shown in Fig. 11 gas flow may be

between the spokes supporting the spacer 6" and through the perforations in the membrane 5, but in other constructions gas flow may be through apertures (not shown) formed in the membrane 4 or in the spacers 6, 6'.

The particular direction of the gas flow will be determined to the particular use by which the gas flow generator is put in practise.

In examples tested to date, perforations with a hole size of 50 to 150μm at a pitch of 350 to 800μm have been utilised, together with a driver operating with a 5μm amplitude. It is expected that operation with smaller diameter holes and correspondingly smaller diameter pitch between the holes, for example 10μm diameter at 100μm pitch could also be used.

Although stainless steel has been used for the membranes shown in the examples, other materials such as Kapton and brass may be utilised where desirable or acceptable.

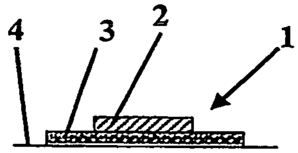


Fig. 1

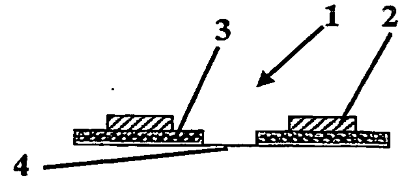


Fig. 2

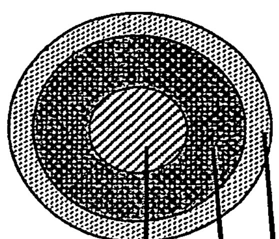


Fig. 3

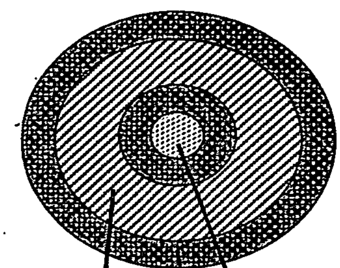


Fig. 4

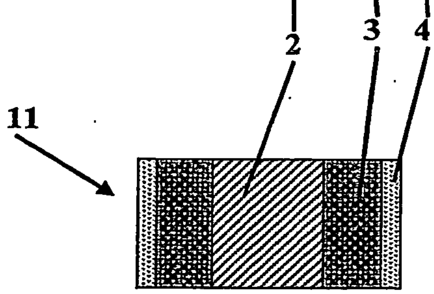


Fig. 5

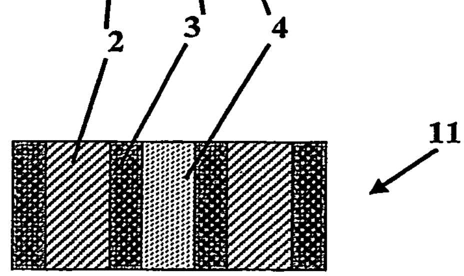


Fig. 6

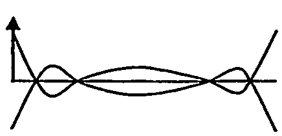


Fig. 7

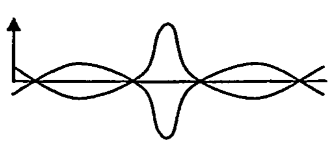


Fig. 8

Fig. 9

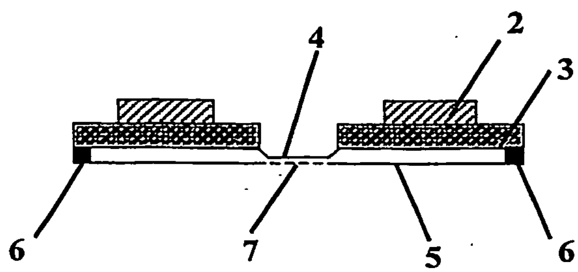


Fig. 10

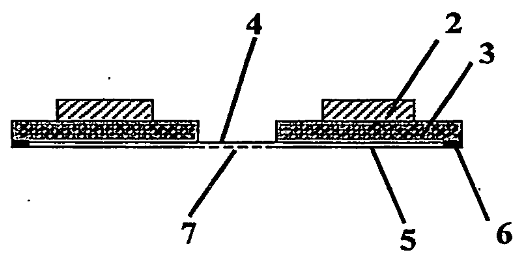
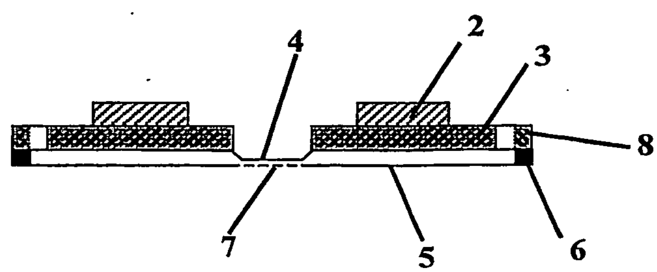


Fig. 11



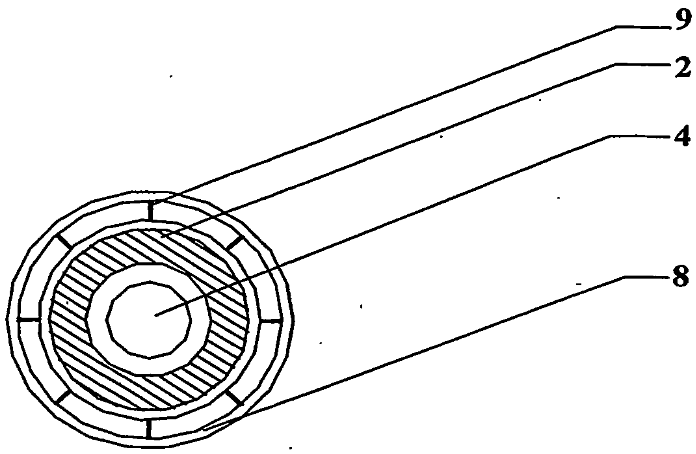


Fig. 12

Fig. 13

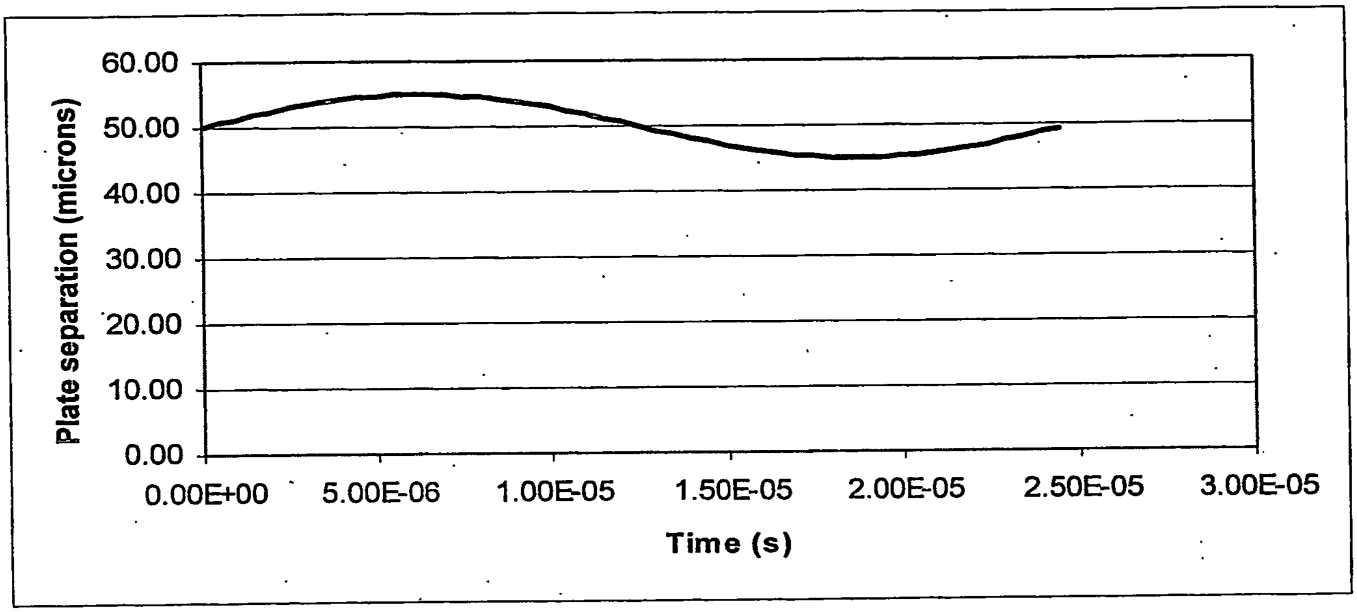
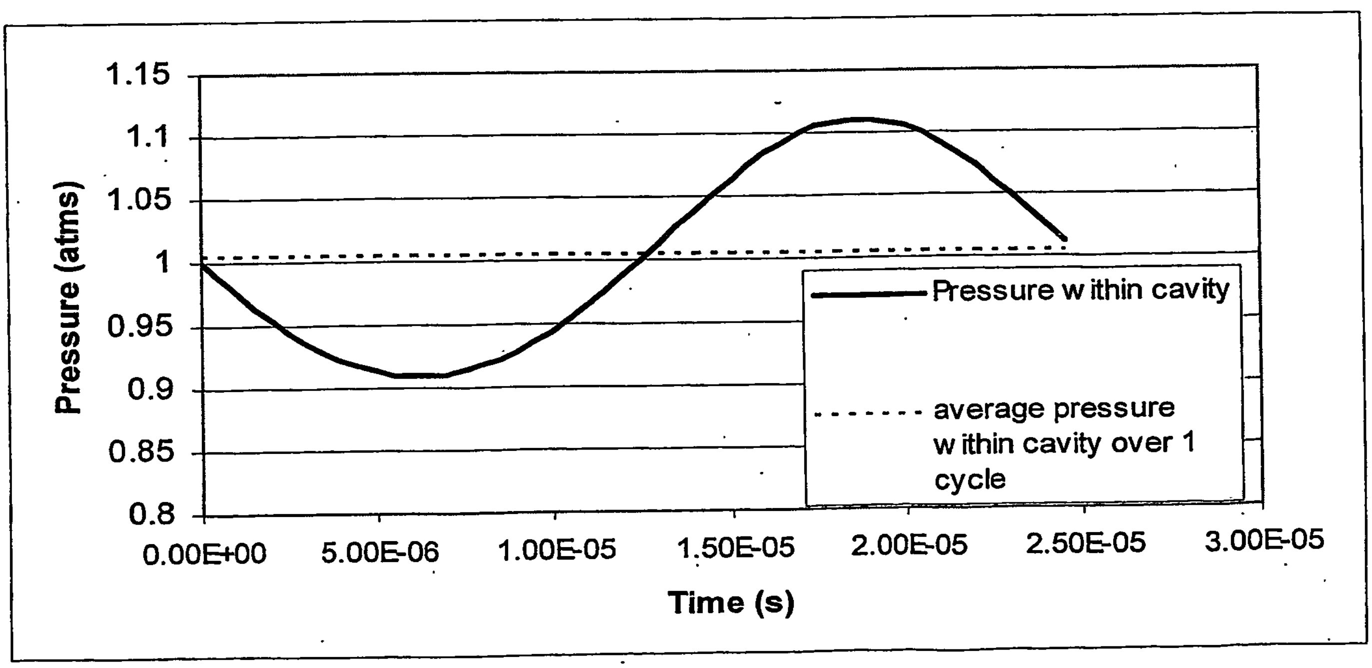

60.00
50.00
40.00
30.00
20.00
10.00
0.00
Plate separation (microns)
0.00E+00
5.00E-06
1.00E-05
1.50E-05
2.00E-05
2.50E-05
3.00E-05
Time (s)

Fig. 14


1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
Pressure (atms)
Pressure within cavity
average pressure within cavity over 1 cycle
0.00E+00
5.00E-06
1.00E-05
1.50E-05
2.00E-05
2.50E-05
3.00E-05
Time (s)

PCT/GB2004/001526